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(54) SYSTEM FOR DATA COMPRESSION BY DUAL WORD CODING HAVING PHOTOSENSITIVE MEMORY AND ASSOCIATED SCANNING MECHANISM

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(54) SYSTEM FOR DATA COMPRESSION BY DUAL WORD CODING HAVING PHOTOSENSITIVE MEMORY AND ASSOCIATED SCANNING MECHANISM

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ABSTRACT:

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SYSTEM FOR DATA COMPRESSION BY DUAL WORD
CODING HAVING PHOTOSENSITIVE MEMORY
AND ASSOCIATED SCANNING MECHANISM

4 Abstract

5 A data compaction method is proposed for encoding run
6 lengths of black and white information (or any two grey levels)
7 as pertaining to facsimile. A mechanical scanner and a semi-
8 conductor memory are joined into a compact solid state device
9 incorporating variable rate scanning with virtually no scanning
10 speed limitations.



11 Background of the Invention and Prior Art

12 Coding

13 Original data has inherent redundancy which can be
14 efficiently reduced by run length encoding, that is, encoding
15 the distance (i.e., length of run) between significant bits.
16 A normal page of text has relatively little information and quite
17 a bit of redundant background.

18 Once obtained, run lengths may be encoded by fixed or
19 variable word length codes. Variable word length codes (such as
20 a Golomb code) are usually more efficient but require more com-
21 putation and are prone to false interpretation due to transmission
22 errors. Fixed word length codes are usually less efficient but
23 generally easier to compute and detect. One class of codes known
24 as linked fixed word length codes combine the favorable points of
25 the two above. This class of codes consists of a fixed word
26 length codeword which can be linked with another codeword of
27 fixed length to form a message. This message is used to indicate
28 a run length longer than the maximum allowable for one word. The

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1 efficiency of these codes are dependent upon the word size used,
2 which in turn is dependent upon the probability distribution of
3 the run lengths. An efficient word length for encoding data ob-
4 tained while scanning at 125 picture elements per inch is four
5 bits long.

6 Typical art in this area is U. S. patent 3,471,639 making
7 use of run length encoding with a format generator and shift
8 registers for handling a limited case transmission situation.
9 The U. S. patent 3,185,824 describes an adaptive compression
10 scheme using run length counting.

11 Memory and Scanner

12 Variable speed scanning is desirable in any high-speed fac-
13 simile machine using redundancy removal techniques to achieve
14 higher rates of information transmission. This is due to the
15 fact that the instantaneous data rate out of the redundancy re-
16 moval encoder may be quite different from the data rate into the
17 encoder from the scanning system. One solution is to scan at the
18 rate of the fastest data rate out of the encoder. This is not
19 feasible because of mechanical speed limitations in most scanner
20 systems. Another solution is to buffer an entire document's worth
21 and look at each bit at the desired rate with the logic involved.

22 Even if the latter solution is used, the scan rate will not
23 be truly variable since data has to be placed in the buffer in a
24 serial-by-bit manner so that the logic may deplate the buffer
25 causing the encoder and, therefore, the transmission system to
26 have to wait until more data becomes available.

27 A typical photo-memory in this area is represented by the
28 U. S. patent 3,689,900.

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1 Summary of the Invention2 Dual Word Coding

3 Up to now the method of encoding the run lengths obtained
4 between information bits has been described, but not the
5 information bits themselves. In most coding schemes these bits
6 are transmitted serially bit by bit, thereby not exploiting
7 their inherent redundancy. In one coding scheme a codeword of
8 length zero is sent every time two black (of information) bits
9 are found together. The proposal herein codes the length of run
10 of these information bits also, also using a linked fixed word
11 length code. This coding scheme is the most optimum scheme found
12 thus far not using inter-line dependency as a means for redundancy
13 removal. In most instances, though, this scheme closely matches
14 the performance obtained by the use of four-point predictive coding
15 with inter-line dependency.

16 The efficiency of the dual word coding scheme will increase
17 as the resolution of scan is increased since the lengths of infor-
18 mation runs will increase due to the increased rate of sampling.
19 For 125 picture elements per inch it can be shown that the dual
20 word coding scheme gives approximately 50% increase in compression
21 ratio over the scheme where only run lengths of white are coded
22 and a run of length zero is inserted between two adjacent infor-
23 mation bits. A four- and a two-bit word length for coding white
24 and black run lengths, respectively, have been used.

25 A matrix full-page memory is used in an effort to eliminate
26 wasted wait time, thereby decreasing the time required for trans-
27 mission of facsimile copy. Furthermore, the buffer cost is
28 effectively halved since only one active device per bit is required
29 instead of the pair of active devices currently used in some de-
30 vices.

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1 Objects

2 The primary object of the present invention is to provide a
3 system for achieving data compression in a highly efficient manner
4 and particularly involving a one-dimensional method of coding in
5 which only a preceding bit of information needs to be stored.
6 Another object of the invention is to provide a photosensitive
7 memory-scanner system of simplified form and offering a variable
8 scan rate and serving as a page buffer.

9 The foregoing and other objects, features, and advantages of
10 the invention will be apparent from the following more particular
11 description of the invention as illustrated in the accompanying
12 drawings.

13 Drawings

14 In the Drawings:

15 Fig. 1 is a facsimile system incorporating various features
16 of the present invention including the dual word coding and the
17 memory-scanner.

18 Fig. 2 illustrates how Figs. 4a and 4b are to be combined
19 for serving as an encoding means based on the dual word concept.

20 Fig. 3 illustrates how Figs. 5a and 5b should be joined
21 serving as a decoding circuit based on the dual word coding tech-
22 niques.

23 Figs. 6-9 illustrate various aspects of the photosensitive
24 memory and scanner portion of the system with Fig. 6 showing a
25 mask of uniformly spaced elements in a matrix array.

26 Figs. 7a and 7b illustrate several versions of the photo-
27 sensitive elements.

28 Fig. 8 is a detailed diagram of the memory-scanner incor-
29 porating photosensitive elements and having provision for addressing
30 particular locations in the memory.

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1 Fig. 9 illustrates the memory of Fig. 8 in actual use as a
2 scanning device for scanning an original document.

3 Detailed Description

4 Illustration of Dual Word Coding

5 The data compaction method proposed for encoding run lengths
6 of black and white information (or any two grey levels) as portsin-
7 ing to facsimile will first be described.

8 This is a one-dimensional method of coding which not only
9 exploits the redundancy contained in the background or white bits
10 of printed material, but which also uses the redundancy inher-
11 ently contained in the information bits as well. This scheme of
12 coding uses a dual word concept, thereby coding the runs of one
13 color with a codeword different from that which is used to code a
14 run of the same length in the opposite color. These codewords
15 are most efficiently assigned after knowing a priori the prob-
16 ability distribution of the run lengths or using a pre-scan or
17 adaptive scheme to obtain them for each separate document. The
18 efficiency of this coding scheme closely matches that obtained by
19 sophisticated two-dimensional schemes as predictive coding using
20 inter-line dependency.

21 Every time that an end of run is detected a flip flop is made
22 to change states. The logic at the encoder or decoder is thus
23 advised that a new run, of color opposite to that of the previous
24 run, is beginning. The logic (either two different sets of logic
25 for each of the two word lengths or one set capable of switching
26 modes) therefore will alternate between encoding or decoding
27 black and white run lengths.

28 At the end of each scan (or periodically at intervals which
29 may be shorter or longer than a scan line depending upon error
30 rate or the transmission medium) an end of scan code is sent
31 using whatever word length is necessary. This is done to signify
32 that a "sync" point needs to be established and that the next run
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1 coded will be of a color arbitrarily specified beforehand. As
 2 could be expected, for most documents this "sync" color will be
 3 white since the margin is the first thing to be sent in each line.
 4 If this first run after the "sync" point is of a color opposite
 5 to that arbitrarily specified, then a run of length zero of the
 6 first color must be sent.

7 The example below uses two specific sets of linked fixed word
 8 length codes, but any set of these codes as well as any other set
 9 of codes for encoding of run lengths could have been used just as
 10 well.

11 An Example of Dual Word Coding

12 Raw Data

13 12 2 5 4 2 7 9
 14 00000000000110000011110011111100000000 Note: 0 = white
 15 b₄z₄ z₂ 5₄ L₂L₂z₄ L₂L₂L₂ 9₄
 16 1 = black

16 Coded Data

17 10110010 01 010111000010111100 1001
 18 b 2 2 S L 1 2 L L 1 9

19 4 Bit Code 20 for White RL

21 0000 = 0
 22 0001 = 1
 23 0010 = 2
 24 0011 = 3
 25 0100 = 4
 26 0101 = 5
 27 0110 = 6
 28 0111 = 7
 29 1000 = 8
 30 1001 = 9

2 Bit Code for Black RL

00 = 1
 01 = 2
 10 = 3
 11 = 4

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1 4 Bit Code (Cont'd)
2 for White RL

3 1010 = A
4 1011 = B
5 1100 = C
6 1101 = D
7 1110 = E
8 1111 = F

9 Typical actual weights assigned to the code words are as follows:

Dual Mode Run Length Code											
White (Pseudo-Hexary)						Black (2 Bit Linked Word)					
Position						Position					
	1	2	3	4		1	2	3			
Symbol					Symbol						
0	0				00	1					
1	1				01	2					
2	2				10	3					
3	3				11		5	3	Link Code		
4	4										
5	5										
6	6										
7	7										
8	8										
9	9										
A	10										
B		0	0	0	Link Codes						
C		11	55	275							
D		22	110	550							
E		33	165	825							
F		44	220	1190							

31

Table Entries Denote Weight

32

Assigned to Each Symbol.

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1 column of information in the memory and to thereafter scan all bits
 2 in the selected column on a bit by bit basis thereby providing an
 3 output in a serial bit by bit manner on output line 10 shown both
 4 in Figs. 1 and 8. The rate of output on line 10 is determined
 5 by the rate of change on the Y address lines 7a. It may be useful
 6 at this point to consider the photosensitive memory in some detail.

7 Memory-Scanner

8 Consider laying out a mask of uniformly spaced elements in a
 9 side by side matrix array form as shown in Fig. 6. This mask
 10 can be changed in size such that its number of elements per
 11 inch becomes the desired resolution rate of scan. Positioning
 12 this mask on some form of substrate or a different material and
 13 vaporizing or depositing on the material some type of photo-
 14 sensitive material is done as shown in Figs. 7a and 7b. Formed,
 15 therefore, is an array of photosensitive elements. This array can
 16 be as large as size and cost limitations permit.

17 When one of these elements is bathed with light, the photo-
 18 sensitive material will generate a current proportional to the
 19 amount of light generated. Each photosensitive element can be
 20 arranged to set or reset the state of a latch pair in a semicon-
 21 ductor memory; with all bits being written into this memory at the
 22 same time. Each bit of this memory can then be addressed as with
 23 any conventional memory except that the time and logic taken to
 24 write serially into it is eliminated.

25 Preferably, instead of using latch pairs as the memory elements
 26 only one sensor device is used per bit such that no memory or
 27 latching capabilities are available unless the inputs to the de-
 28 vice are present. Furthermore, the light source may be con-

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1 trolled such that it can be turned off and on at will. Latching
 2 or remembering capabilities of the memory are therefore unnecessary
 3 since the light could be kept on the photosensor, thereby present-
 4 ing an input to the device, for as long as it takes the encoding
 5 logic to perform its task.

6 Refer again to the detailed diagram in Fig. 8. If desired,
 7 this matrix can be built as large as 8-1/2 inches by 11 inches..
 8 This single-element-per-bit memory is positionable on the under-
 9 side of a substrate holding the matrix, such that the only inter-
 10 connection between the mechanism and the logic are the X and Y
 11 memory address lines and the sense output line, and a simple and
 12 compact way of scanning and buffering data is thereby available.
 13 If a printed page is placed on the array of photosensors and
 14 light shines on it as shown in Fig. 9, any photosensor under an
 15 effectively black area will have no output; while any photosensor
 16 under an effectively white area will have a current generated by
 17 it. The light can be kept on the document until all of the en-
 18 coding logic necessary to describe the printed page without re-
 19 dundancies is performed, at which time the light can be turned
 20 off since the data is no longer necessary. The resolution of the
 21 scanned text will be the number of photosensors per inch.

22 There are several advantages to this device. Since the
 23 device is all solid state, its reliability is inherently better
 24 than most other scanning mechanisms using mechanical moving parts
 25 such as a flat bed scanner or a drum scanner. The compactness
 26 and relative size of the scanner is an advantage over the relatively
 27 large size of other scanners. Since no latching is necessary in
 28 the memory, buffer cost can probably be decreased by a factor of
 29 two. A truly variable scan rate is achieved, thus providing for

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1 faster, and less expensive, facsimile transmission through the
2 use of redundancy reduction in the encoding of source data.

3 Dual Mode Encoder, Figs. 4a and 4b

4 Continuing with the operation of the facsimile system in
5 Fig. 1, raw data on line 10 is provided to the dual mode encoder
6 shown in greater detail in Figs. 4a and 4b. The algorithm upon
7 which the coding scheme is based is indicated below.

8 Algorithm

9 Every time that an end of run is detected a flip flop is made
10 to change states. The logic at the encoder or decoder is thus
11 advised that a new run, of color opposite to that of the previous
12 run, is beginning. The logic (either two different sets of logic
13 for each of the two word lengths or one set capable of switching
14 modes) therefore will alternate between encoding or decoding black
15 and white run lengths.

16 At the end of each scan (or periodically at intervals which
17 may be shorter or longer than a scan line depending upon error
18 rate of the transmission medium) an end of scan code is sent using
19 whatever word length is necessary. This is done to signify that
20 a "sync" point needs to be established and that the next run
21 coded will be of a color arbitrarily specified beforehand. As
22 could be expected, for most documents this "sync" color will be
23 white since the margin is the first thing to be sent in each
24 line. If this first run after the "sync" point is of a color
25 opposite to that arbitrarily specified, then a run of length
26 zero of the first color must be sent.

27 The circuits of Figs. 4a and 4b include a data register 12,
28 a transition register 13, a control unit 14, a clock 15, a back-
29 ground word counter 17, a background run length counter block 18, an

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1 information run length counter 19, and an output buffer and serial-
 2 izer 20. The raw data 10 is inputted into the data register 12.
 3 At the clock rate specified by clock 15, data is supplied to the
 4 transition detector 13 on line 22. The transition detector 13 will
 5 specify on line 23 when a transition has occurred from one data
 6 color to another or from information to background and vice versa
 7 and will specify on line 24, what the color of the transition is.
 8 At the same time, data register 12 will detect on line 25 when the
 9 end of the present scan occurs and on line 27 when the end of
 10 the page has occurred. On line 30, the control unit will signify
 11 to the data register when it should be able to give data to the
 12 transition detector. At the same time on line 31, the data regis-
 13 ter will tell the control unit when no data is available for
 14 transmission.

15 As previously noted, the control unit 14 provides a scanner
 16 control signal on line 8 to tell the scanner when it should provide
 17 data to the data register 12. Depending on the color of data that
 18 the control unit is presently working on, a pulse will come to the
 19 run length counters for either the background counters 18 or infor-
 20 mation counter 19 on lines 32 and 33, respectively, because of the
 21 dual base technique used. If a new word is needed for the run
 22 length presently being worked on, a pulse is placed on line 37 tell-
 23 ing the background word counter 17 that a new word is being used and
 24 needs to be transferred when a transition occurs. When a transi-
 25 tion occurs on line 23, such that the new word is going to be in-
 26 formation, the run length counted in run length counters 18 needs
 27 to be transferred to the output buffer and serializer 20 using four
 28 data lines 38. To accomplish this purpose, the control unit 14
 29 places a signal on line 36 telling the run length counters 18 to
 30 transfer a background word of information to the output buffer and

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1 serializer 20. The particular word transferred is determined
 2 by the state of the background word counter on line 40. As a word
 3 is transferred to the output buffer and serializer 20, the present
 4 word being worked on in the background word counter 17 is counted
 5 down and the new state of the background word counter is placed on
 6 bus 40 to the run length counter 18. When the state of bus 35
 7 from the background word counter 17 to the control unit 14 becomes
 8 zero, it is then known that the last background word used was trans-
 9 ferred and counting of the information run length needs to proceed
 10 using counter 19. When counting an information word length, a
 11 signal is placed on line 33, the black count enable line, to tell
 12 the information run length counter 19 to count up. When the infor-
 13 mation run length counter 19 gets to the largest word size that it
 14 can count, it will place a pulse on line 41 requesting a transfer
 15 code. As control unit 14 sees that the output buffer and serial-
 16 izer 20 can accept a new word, it will place a signal on line 42
 17 representing a transfer code command. Upon this signal, the infor-
 18 mation run length counter will transfer the information code to the
 19 output buffer and serializer 20, on the line pair 43.

20 If the output rate of the buffer and serializer 20 is less
 21 than the input rate, it may fill. If the buffer fills, a signal is
 22 placed on line 45 from output buffer and serializer 20 to the con-
 23 trol unit 14. A signal on this line signifies that no more codes
 24 can be placed in the output buffer and serializer and the hard-
 25 ware must go into an idle state until some codes are put into the
 26 transmission line through the modem using line 50, whereupon some
 27 new space will be available in the output buffer and serializer 20
 28 and the coding operation will continue.

29 The system makes use of special codes for several reasons
 30 which are not determined by the length of the run presently being

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1 worked on. To take advantage of these special codes, a "special
2 code force" signal on lines 46 going from the control unit 14 to
3 the background run length counter 18 and the background word
4 counter 17 has been provided. This line is used to set a specific
5 pattern on the run length counter and the transfer of this pattern
6 to the output buffer and serializer 20 will proceed in the same
7 manner that an actually counted run length is transferred.

8 Transmission of Information

9 The coded data on line 50 is provided to a transmitter 52,
10 Fig. 1 for transmission by way of communication lines 53 to a
11 receiver unit 54 in a manner known in the art. Coded data is pro-
12 vided from receiver 54 on line 56 to the dual mode decoder de-
13 signated 60 and shown in greater detail in Figs. 5a and 5b.

14 Dual Mode Decoder

15 In Figs. 5a and 5b, coded data arrives on line 56 to an input
16 buffer 61. A deserializer 62 serves to accumulate coded words at
17 the length required for decoding. The circuits further include
18 a background word counter 64, a block of background run length
19 counters 66, an information run length counter 67, a control unit
20 70, an associated clock circuit 71, and a print buffer 72. Buffer
21 72 has sufficient capacity to store one line of information. Some
22 of these units, such as control unit 70 and print buffer 72 are
23 also illustrated in Fig. 1.

24 Input data on a serial bit by bit manner comes into the input
25 buffer 61 from the modem on line 56. Data from the input buffer
26 goes into the deserializer on line 63 at the clocking rate as
27 shown on line 65. Line 68 from input buffer 61 will tell the control
28 unit 70 if the buffer is empty and no data is available for decoding.

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1 This may happen many times throughout the transmission of a
 2 document since the transmission rate of the modem is slower than
 3 the decoding rate of the system. The deserializer converts the
 4 serial bit by bit data into word lengths capable of being decoded
 5 by the existing set up. A data color line 69 from the control unit
 6 70 to the de-serializer 62 will let the de-serializer know the
 7 length of the word that it needs to create depending upon whether
 8 it is background or information. As that word is created, it is
 9 placed on data bus 75 and depending upon the state of line 69, it
 10 will either be placed in the background run length counters or the
 11 information run length counter. Using signals on lines 77 and 78
 12 signifying the loading of background and the loading of information
 13 code, respectively, the bus 75 also enters the control unit whereby
 14 the actual word is decoded. A signal on line 79 controls counting
 15 by counters 66. If the word coming in is a high order word, in
 16 other words, signifying that another word of that same color is due
 17 to arrive, the control unit 70 will not enable the background run
 18 length counters to count thru line 79, but rather to wait until
 19 the new code arrives. When the low order code for the background
 20 run length counter arrives, the background count enable signal
 21 on line 79 will be activated and the background run length
 22 counters will start counting down at the clock rate. Every time
 23 that a new word is loaded into one of the background run length
 24 counters 66, a signal is placed on line 80 to the background
 25 word counter 64 to signify that a new word position of the run
 26 length counters was used. In turn, the background word counter 64
 27 will place on the pair of lines 82, the present word position used.
 28 As the background run length counters count the length of the input
 29 word, a "zero" bit is placed by the control unit 70 on line 84 to
 30 the print buffer 72. This bit is kept on line 84 for every
 31 clock time until a signal is placed in the control unit on line 86



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1 by the background run length counter 66 to signify that its count
 2 has reached zero. It is assumed that as each low order run length
 3 counter reaches zero, the background word counter 64 will count
 4 down one and that no signal will be placed on the background-count-
 5 equal-to-zero line 86 until all the words of the run length are
 6 zero.

7 The information run length counter works essentially in the
 8 same manner as the background run length counters and the back-
 9 ground word counter. As the control unit places a signal on line
 10 78 to the information run length counter 67, two bits of the data
 11 bus 75 are placed in the register of the information run length
 12 counter 67. A signal is provided on line 88, signifying to the
 13 run length counter 67 that it is enabled to count the information
 14 word. The counting down of this word proceeds at the clock rate
 15 and the control unit places a "1" bit on line 84 to the print
 16 buffer 72 for every information run length count. This process
 17 continues until the information run length counter 67 places a
 18 signal on line 90 to the control unit 70 signifying that the in-
 19 formation count is now zero. The control unit 70, remembering
 20 whether the word in the information run length counter was a high
 21 order or a low order information word, will or will not change the
 22 state of flip flop 91 to tell the de-serializer 62 whether the next
 23 word should be a four bit background word or a two bit information
 24 word that needs to be placed on data bus 75.

25 As the run length is being counted down by the various
 26 counters no new data can come into the de-serializer 62 from the
 27 input buffer 61 on data line 63. To prevent this, a line 92 called
 28 input enable signals the input buffer when it can load data into
 29 the de-serializer 62 on data line 63.

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1 An end of scan signal or end of page signal from the photo-
2 sensitive scanner memory are signified by special codes by the
3 dual word encoder. When control unit 70 of the dual mode decoder
4 detects one of these two special codes, it places a signal on
5 lines 93 or 94 to signify to the print buffer 72 that either an
6 end of scan or an end of page condition was detected. Upon an
7 end of scan condition, the print buffer releases the line of data
8 it is holding to printer 96 via line 73.

9 The printer 96 comprises a cylindrical member 100 mounting
10 a record sheet 101 and an associated print head 102 driven by
11 means 103 such as a lead screw or the like. Means 103 in turn is
12 driven by motor 104 that also drives cylindrical member 100.
13 The operation of the printer 96 is such that individual lines of
14 information are projected by print head 102 onto document 101 on
15 a line by line basis by relatively moving member 100 and print
16 head 102 in order to ultimately form an entire page of information.
17 Whenever print buffer 72 has an entire line of information, this
18 is indicated to control unit 70, on the buffer full line 98.
19 Control unit 70 signals print buffer 72 on line 97 to release data
20 to the printer 96.

21 In summary, the one-dimensional method of coding not only
22 exploits the redundancy contained in the background or white bits
23 of printed material, but also uses the redundancy inherently con-
24 tained in the information bits as well. This scheme of coding
25 uses a dual word concept, thereby coding the runs of one color with
26 a codeword different from that which would be used to code a run
27 of the same length in the opposite color. These codewords are most
28 efficiently assigned after knowing a priori the probability dis-
29 tribution of the run lengths or using a pre-scan or adaptive scheme

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1 to obtain them for each separate document. The efficiency of this
2 coding scheme closely matches that obtained by sophisticated
3 two-dimensional schemes such as predictive coding using interline
4 dependency.

5 The example described herein uses two specific sets of linked
6 fixed word length codes, but any set of these codes as well as
7 any other set of codes for encoding of run lengths could have
8 been used just as well.

9 By incorporating the photosensitive memory-scanner, previously
10 discussed, a highly efficient system is realized.

11 While the invention has been particularly shown and described
12 in connection with a preferred embodiment thereof, it will be
13 evident to skilled in the art that various changes in form and
14 detail may be made without departing from the spirit and scope of
15 the invention.

16 What is claimed is:



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The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Dual mode compression apparatus for data processing in a facsimile system or the like, said data being classified into at least two types of data, such as background data and information data in an original document, comprising:

a data source, said data source providing raw data in said at least two types in the form of binary digits 0 and 1, where typically 0 bits represent background data and 1 bits represent information data in said original document;

first run-length encoding means for encoding a first of said types of data using a first set of fixed length data code words wherein each of said first set of fixed length data code words is four bits long and is pre-assigned on a probability distribution of various run lengths of said first data type and including a first set link code word;

second run-length encoding means for encoding a second of said types of data using a second set of fixed length data code words wherein each of said second set of fixed length data code words is two bits long and is pre-assigned on a probability distribution of various run lengths of said second data type and including a second set link code word;

first link means for monitoring encoding of data and responsive to any run-length of said first type of data exceeding the run-length capacity of said first set of code words for providing one or more of said first set link code words and at least one data code word solely from said first set of code words to represent said exceeding run-length of said first type of data; and

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second link means for monitoring encoding of data and responsive to any run-length of said second type of data exceeding the run-length capacity of said second set of code words for providing one or more of said second set link code words and at least one data code word solely from said second set of code words to represent said exceeding run-length of said second type of data.

2. The apparatus of claim 1, further comprising:

a photomemory having a plurality of sensor means arranged in matrix format in an array at least as large as an original document to be sensed;

means for positioning an original document adjacent said photomemory; and

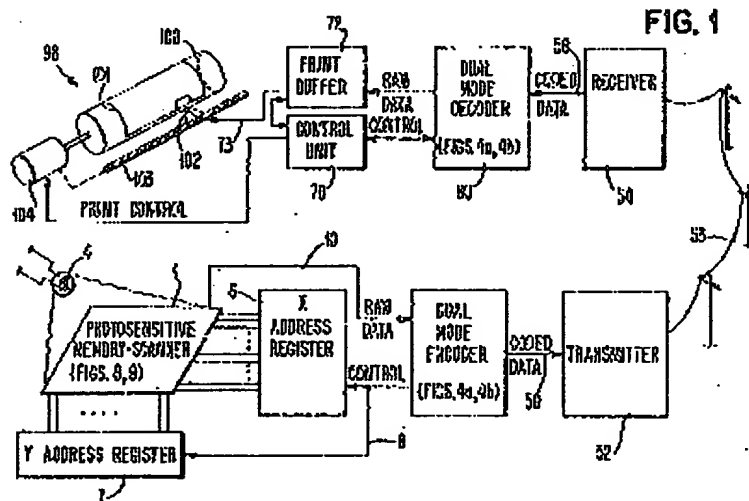
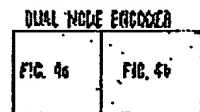
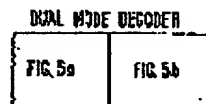
scanning means for initiating a serial scanning operation of said photomemory in order to provide said two types of data for encoding purposes.

3. The apparatus of claim 1, further comprising:

means for transmitting said data words;

first run-length decoding means for decoding a first of said types of data using said first set of fixed length code words; and

second run length decoding means for decoding a second of said types of data using said second set of fixed length code words.

**FIG. 2****FIG. 3**

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FIG. 4a

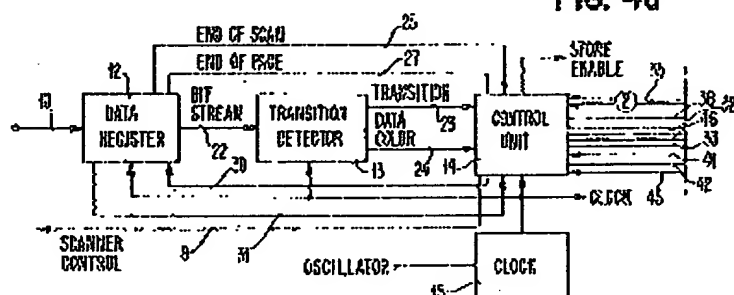
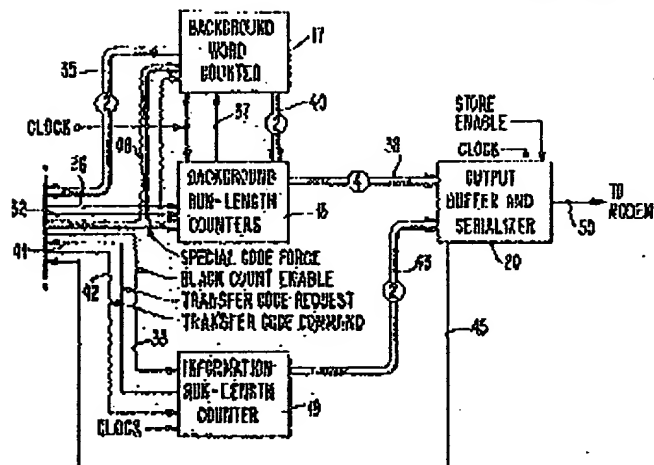
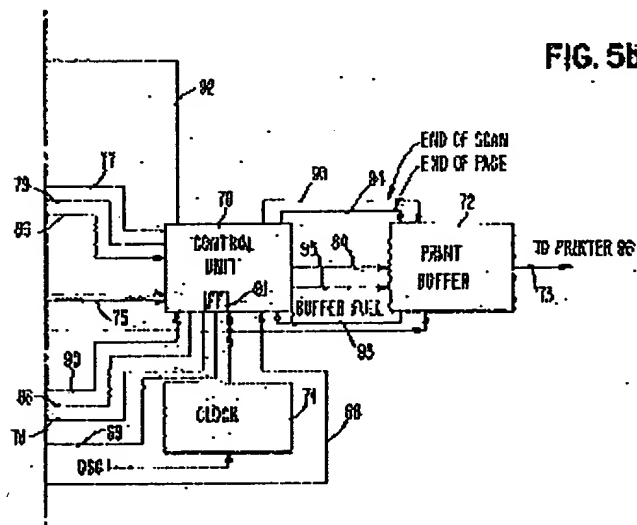
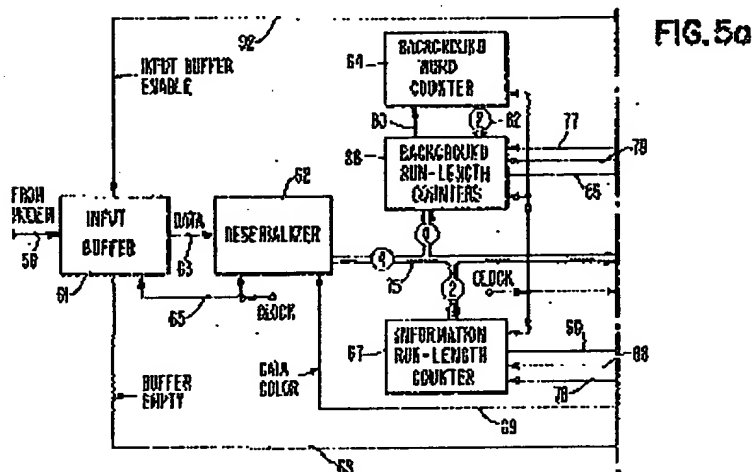


FIG. 4b



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FIG. 6



FIG. 7a

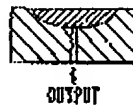


FIG. 7b

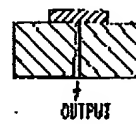


FIG. 8

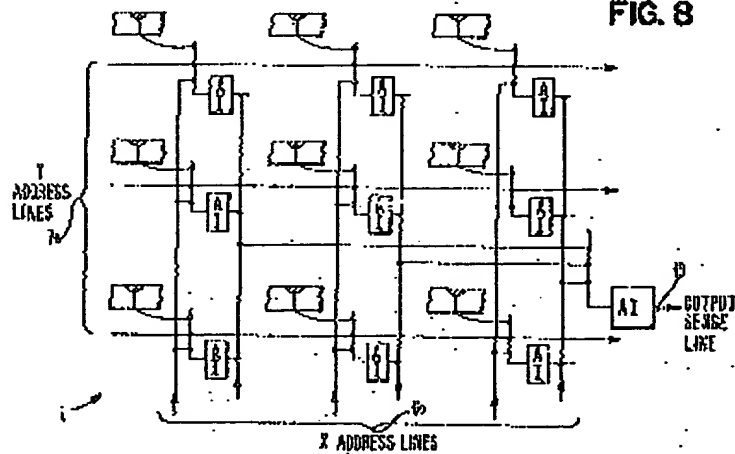
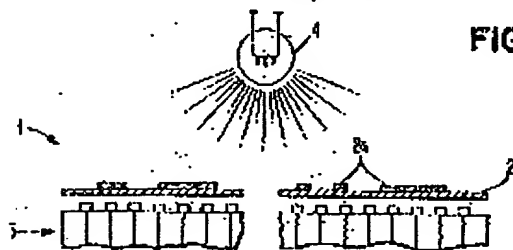


FIG. 9



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